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Science 20-30

FIELD VALIDATION DRAFT

Program of Studies

This document is a field validation draft, being used to prepare support material and to validate the program of studies.

CB 92 02 11

Vision
Senior High
Science Programs

The senior high science programs will help all students attain the scientific awareness needed to function as effective members of society. Students will be able to pursue further studies and careers in science, and come to better understand themselves and the world around them. To achieve this, appropriate curriculum components are identified, and approached from a common philosophical position in each science course. These components include expected student knowledge, skills and attitudes.

The senior high science programs focus on students learning the big interconnecting ideas and principles. These ideas, or major principles, originate from science knowledge that transcends and unifies the natural science disciplines. These major ideas include change, diversity, energy, equilibrium, matter and systems; the process by which scientific knowledge is developed including the role of experimental evidence; and the connections among science, technology and society. The ideas will also form a framework for the curriculum, provide continuity with the junior high program and build on students' previous learning.

The senior high science programs place an increased emphasis on developing methods of inquiry that characterize the study of science. For example, students will further their ability to ask questions, investigate and experiment; gather, analyze and assess scientific information; and test scientific principles and their applications. They will develop their problem-solving ability and use technology appropriately. By providing students with opportunities to develop and apply these skills, they will better understand the knowledge they have acquired.

Students will be expected to develop an appreciation for the roles of science and technology in understanding nature that will help them maintain a lifelong interest in science. They will possess positive attitudes toward and an enthusiasm for science.

The learning context is an integral part of the senior high science programs. The context is intended to foster the expected attitudes in students, further the development of students' skills and increase students' understanding of science knowledge, science process, and the connections among science, technology and society. The context for learning will be relevant to students' lives so they will experience science as interesting and dynamic. Learning opportunities will be made meaningful by providing concrete experiences that students can relate to their world.

The senior high science programs place students at the centre. Students are active learners and will assume increased responsibility for their learning.

This framework was used for the development of programs including Science 10–20–30, Biology 20–30, Chemistry 20–30, Physics 20–30, Science 14–24 and Science 16–26. The programs have a common rationale and philosophy, goals and general learner expectations. As well, each program will have specific learner expectations and standards of achievement.

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Science 20-30

PROGRAM RATIONALE AND PHILOSOPHY

Science by its very nature is interesting, exciting and dynamic. Through the study of science students are given the opportunity to explore and understand the natural world and to become aware of the importance of science to their lives. Meaningful learning takes place when the study of science relates to what learners already know, deem personally useful and consider relevant. Young people learn best from concrete experiences that present an authentic view of science. In Science 20–30 students learn science in relevant contexts and engage in meaningful activities. This facilitates the transfer of knowledge to new contexts. Students are encouraged to participate in lifelong scientific learning and to appreciate science as a remarkable, inspiring and stimulating human enterprise with practical impact on their lives and on society as a whole.

Science is experimental, creative and imaginative; methods of inquiry characterize the study of science. In Science 20–30, students further develop their ability to ask questions, investigate and experiment; to gather, analyze and assess scientific information; to test scientific laws and principles and their applications. In the process, students exercise their creativity and develop critical thinking skills. Through experimentation, problem-solving activities and independent study, students develop an understanding of the processes through which scientific knowledge evolves.

The Science 20–30 program places students at the centre. Students are active learners and will assume increased responsibility for their learning as they work through the program. A thorough study of science is required to give students an understanding of science that encourages them to make appropriate applications of scientific concepts to their daily lives. Students are expected to participate actively in their own learning; teachers act as collaborators or guides. An emphasis on the key concepts and principles of science provides students with a more unified view of the natural sciences and a greater awareness of the connections among them.

Goals

The major goals of the Science 20–30 program are:

- to develop in students an understanding of the big interconnecting ideas and principles that transcend and unify the natural science disciplines
- to provide students with an enhanced understanding of the scientific world view, inquiry and enterprise
- to help students attain the level of scientific awareness that is essential for all citizens in a scientifically literate society
- to help students make informed decisions about further studies and careers in science
- to provide students with opportunities for acquiring knowledge, skills and attitudes that contribute to personal development.

Science 20–30 is an integrated academic program that helps students better understand and apply the fundamental concepts and skills that are common to biology, chemistry, physics and earth science. The focus is on helping students understand the scientific principles behind the natural events they experience and the technology they use in their daily lives. The program encourages enthusiasm for the scientific enterprise and develops positive attitudes about science as an interesting human activity with personal meaning. It develops in students the attitudes, skills and knowledge to help them become capable of and committed to, setting goals, making informed choices and acting in ways that will improve their own lives and life in their communities.

GENERAL LEARNER EXPECTATIONS

The general learner expectations outline the many facets of scientific awareness and serve as the foundation for specific learner expectations. The general learner expectations are developed through the study of individual units in Science 20-30, where attitudes, skills and knowledge develop concurrently.

Attitudes

Students will be encouraged to develop:

- an enthusiasm for, and a continuing interest in, science
- the effective attributes of scientists at work; such as, respect for evidence, tolerance of uncertainty, intellectual honesty, creativity, perseverance, co-operation, curiosity and a desire to understand
- positive attitudes toward scientific skills involving mathematics, problem-solving and process skills
- open-mindedness and respect for others' points of view
- a sensitivity to the living and non-living environment
- an appreciation for the roles of science and technology in our understanding of the natural world.

Skills

Students will be expected to develop an ability to use thinking processes associated with the practice of science for understanding and exploring natural phenomena, problem solving, and decision making. These processes involve many skills that are to be developed within the context of the program content.

The skills framework presented here assumes that thinking processes often begin with an unresolved problem or issue or an unanswered question. The problem, issue or question is usually defined and hypotheses formulated before information gathering can begin. At certain points in the process the information needs to be organized and analyzed. Additional ideas may be generated – for example, by prediction or inference – and those new ideas when incorporated with previous learning can create a new knowledge structure. Eventually, an outcome such as a solution, an answer or a decision is reached. Finally, criteria are established to judge ideas and information to assess both the problem-solving process and its outcomes.

The following skills are not intended to be developed sequentially or separately. Effective thinking appears to be non-linear and recursive. Students should be able to access skills and strategies flexibly; select and use a skill, process or technology that is appropriate to the task; and monitor, modify or replace it with a more effective strategy.

- Initiating and Planning
  - identify and clearly state the problem or issue to be investigated
  - differentiate between relevant and irrelevant data or information
  - assemble and record background information
  - identify all variables and controls
  - identify materials and apparatus required
  - formulate questions, hypotheses and/or predictions to guide research
  - design and/or describe a plan for research or to solve the problem
  - prepare required observation charts or diagrams
- Collecting and Recording
  - carry out and modify the procedure if necessary
  - organize and correctly use apparatus and materials to collect reliable experimental data
  - accurately observe, gather and record information or data according to safety regulations (e.g., WHMIS) and environmental considerations
- Organizing and Communicating
  - organize and present data (themes, groups, tables, graphs, flow charts and Venn diagrams) in a concise and effective form
  - communicate data more effectively, using mathematical and statistical calculations where necessary

- express measured and calculated quantities to the appropriate number of significant digits, and use appropriate SI units for all quantities
- communicate the findings of their investigations in a clearly written report

- Analyzing
  - analyze data on information for trends, patterns, relationships, reliability and accuracy
  - identify and discuss sources of error and their effect on results
  - identify assumptions, attributes, bias, claims, or reasons
  - identify main ideas

- Connecting, Synthesizing and Integrating
  - predict from data or information
  - formulate further testable hypotheses supported by the knowledge and understanding generated
  - identify further problems or issues to be investigated
  - identify alternatives for consideration
  - propose and explain interpretations or conclusions
  - develop theoretical explanations
  - relate the data or information to laws, principles, models or theories identified in background information
  - answer the problem investigated
  - summarize and communicate findings
  - decide on a course of action

- Evaluating the Process or Outcomes
  - establish criteria to judge data or information
  - consider consequences and perspectives
  - identify limitations of the data, and information, interpretations or conclusions as a result of the experimental/research/project/design processes or methods used
  - suggest alternatives and consider improvements to experimental technique and design
  - evaluate and assess ideas, information and alternatives

Further Reading

For a more detailed discussion on how to integrate thinking and research skills into the science classroom, refer to the Alberta Education publications: *Teaching Thinking: Enhancing Learning* (1990) and *Focus on Research* (1990).

Know_ ıge

Science Themes

Students will be expected to demonstrate an understanding of themes that transcend the discipline boundaries and show the unity among the natural sciences, including:

- Change: how all natural entities are modified over time, how the direction of change might be predicted and, in some instances, how change can be controlled
- Diversity: the array of living and non-living forms of matter and the procedures used to understand, classify and distinguish those forms on the basis of recurring patterns
- Energy: the capacity for doing work, which drives much of what takes place in the universe through its variety of interconvertible forms
- Equilibrium: the state in which opposing forces or processes balance in a static or dynamic way
- Matter: the constituent parts and the variety of states of the material in the physical world
- Systems: the interrelated groups of things or events that can be defined by their boundaries and, in some instances, by their inputs and outputs.

Science, Technology and Society (STS)

Students will be expected to demonstrate an understanding of the processes by which scientific knowledge is developed, and of the interdependent relationships of science, technology and society, including:

- the central role of experimental evidence in the accumulation of knowledge, and the way in which proposed theories may be supported, modified or refuted
- the inability of science to provide complete answers to all questions
- the functioning of products or processes based on scientific principles
- the ways that science advances technology and technology advances science
- the use of technology to solve practical problems
- the limitations of scientific knowledge and technology
- the influence of the needs, interests and financial support of society on scientific and technological research
- the ability and responsibility, through science and technology, that society has to protect the environment and judiciously use natural resources to ensure quality of life for future generations.

Further Reading

For further reading on integrating science, technology and society into the classroom refer to the Alberta Education publication: *STS Science Education: Unifying the Goals of Science Education* (1990).

SPECIFIC LEARNER EXPECTATIONS

Learning Cycle

The specific learner expectations consist of the attitudes, skills and knowledge that are to be addressed in Science 20–30. The use of the learning cycle allows students to progress from:

- an introduction that frames a lesson in an STS connection that is relevant to the lives of the learners, to
- the experiential exploration of a new idea or content, through
- hypothesis-building stage where concepts are developed to describe the results of the initial exploration, to
- an application phase where the hypothesis, vocabulary and patterns previously developed are applied to new situations and related to key concepts and principles of science, to
- a final evaluation of the significance of the new learning in an STS context.

Students examine phenomena in a variety of areas to show the relationships among the traditional science disciplines. Wherever possible, examples are drawn from their own experience to enable students to make the connection between scientific knowledge and the society around them, the technology that societies have developed, and the nature of science itself.

PROGRAM OVERVIEW

The Science 20–30 program emphasizes the key concepts of science: *energy*, *matter*, *change*, *systems*, *diversity* and *equilibrium*. These conceptual themes provide a means of showing the connections among the scientific disciplines, and provide a framework for teachers to show students how individual sections of the program relate to the big ideas of science.

In addition to developing a solid understanding of fundamental science concepts and principles, Science 20–30 has the goal of educating students about the nature of science and about the interaction of science and technology. Students must be aware of the tremendous impact of science and technology on society, but at the same time must be aware of the roles and limitations of science and technology in STS problem solving.

Science 20

Change is the theme common to all the units in Science 20. Analysis of *change* is essential for understanding what is happening and for predicting what will happen; and control of *change* is essential for the design of technological *systems*. The principles of conservation of mass, *energy* and momentum help to predict and explain the *changes* that occur in a closed *system*.

Science 20 consists of four units of study:

Unit 1: The Changing Earth;
Unit 2: Changes in Living Systems;
Unit 3: Chemical Changes; and
Unit 4: Changes in Motion.

Each unit in Science 20 uses a different context to investigate the processes by which natural entities and *systems* are modified over time, and to identify common patterns of *change*. In Unit 1 geologic evidence is used to study the patterns of *change* that have occurred in the biosphere over the entire span of Earth's history. Unit 2 examines ongoing *change* in the biosphere, focusing on the flow of *matter* through biogeochemical cycles and the flow of *energy* through the trophic levels of an *ecosystem*. In Unit 3, the principles of chemical *change* are investigated and their application in chemical industry is examined. Unit 4 investigates the relationship between force and the motion of objects, using Newton's laws and conservation of momentum to explain and predict *changes* in motion.

Science 30

The themes of *systems* and *energy* run through all the units of Science 30. Thinking of any collection of objects, cells or processes as a *system* draws attention to how the parts of the *system* interact with one another. The components of a *system* influence each other not only by transfer of *matter* and *energy* but also by transfer of information.

Science 30 consists of four units of study:

Unit 1: Living Systems Respond to Their Environment;
Unit 2: Chemistry in the Environment;
Unit 3: Electromagnetic Energy; and
Unit 4: Energy and the Environment.

That making *changes* in one part of a *system* can cause profound *changes* in other parts of the *system* is illustrated in different contexts in each unit of Science 30. Unit 1 uses the human organism to illustrate some of the mechanisms that enable living *systems* to respond to *changes* in their environment. Unit 2 introduces environmental chemistry, focusing on the impact of acids, bases and organic compounds on *ecosystems*. In Unit 3 electromagnetic *energy* is studied and its use in communication and scientific research is illustrated. Unit 4 examines the range of renewable and non-renewable *energy* sources available for commercial use and considers the impact of their use on the global *ecosystem*.

Science 20

Unit 1 The Changing Earth

Overview

Science Themes: *Change* and *Diversity*

In Unit 1, evidence is examined that indicates that *diverse* climatic conditions and life forms have existed on Earth during the last 3.5 billion years. Some of the theories that have been developed to explain these *changes* are considered and evaluated. Evidence from the polar ice caps is used to construct a picture of the cyclic *changes* that have occurred in the biosphere over the last one hundred thousand years.

This unit builds upon Science 8, Unit 4: The Earth's Crust, and Science 10, Unit 1: Energy from the Sun, and provides students with a foundation for the study of energy sources in Science 30, as well as the further study of biology and earth science.

The four **major concepts** developed in this unit are:

- forces within Earth cause continual *changes* in Earth's surface
- paleontology, the scientific study of ancient life, uses fossils as the primary source of data
- the fossil record indicates that the environment and life forms on Earth have undergone a sequence of *changes* over more than 3.5 billion years
- the geologic record indicates that huge glaciers have formed in Arctic regions and flowed south over large areas of Canada several times over the last two million years.

In this unit, students will develop an ability to use the **skills** and **thinking processes** associated with the practice of science, including:

- analyzing data
- connecting, synthesizing and integrating data
- evaluating the process of investigating the ancient biosphere.

The **STS connections** in this unit illustrate:

- the ways that science advances technology and technology advances science
- the limitations of scientific knowledge and technology
- the ability and responsibility, through science and technology, that society has to protect the environment and judiciously use natural resources to ensure quality of life for future generations.

Attitudes

Students will be encouraged to:

- develop a questioning attitude concerning changing life forms and environmental conditions on Earth
- look for consistency in the data coming from different geological sources
- respect the role of empirical evidence in developing scientific theories related to changing life forms and environmental conditions
- consider all the evidence available when evaluating scientific theories related to changing life forms and environmental conditions
- appreciate the unity of science through the application of biological, chemical and physical principles and techniques to investigating the history of the biosphere
- recognize the limits of current scientific theories in predicting future environmental conditions on earth
- consider several possible alternatives when predicting future environmental conditions on earth.

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MAJOR CONCEPTS	KNOWLEDGE
	Students should be able to demonstrate an understanding that:

1. **Forces within the Earth cause continual changes on the Earth's surface.**	• forces deep within the Earth cause continual changes on the Earth's surface by:
	  • identifying and describing the three layers of the Earth: lithosphere, asthenosphere and the mesosphere, in terms of density, composition and thickness
	  • describing the theory of plate tectonics, identifying pieces of evidence (e.g., location of volcanoes and earthquakes, ocean floor spreading, patterns in mountain structure) that support the theory
	  • explaining how convection circulation of molten material provides the driving force of plate tectonics
	  • explaining how the energy from earthquakes is transmitted by seismic waves
	  • explaining that seismic waves can be:
	  – longitudinal (particles vibrate parallel to the direction of propagation)
	  – transverse (particles vibrate perpendicular to the direction of propagation)
	  • explaining how the seismic waves can provide information about the internal structure of the Earth
	  • explaining why the Earth's first atmosphere was composed of gases released from volcanoes

SKILLS

Students should be able to demonstrate the skills and thinking processes associated with the practice of science by:

- comparing the magnitude of earthquakes, given their rating on the Richter scale
- evaluating the theory of plate tectonics in terms of its ability to explain and predicting changes in the Earth's surface
- using a "slinky" spring to demonstrate the difference between primary and secondary earthquake waves
- reporting the findings of their investigations in a clearly written report

STS CONNECTIONS

Students should be able to demonstrate an understanding of the processes by which scientific knowledge is developed and of the interrelationship of science, technology and society by, among other activities:

- discussing a recent earthquake in terms of the theory of plate tectonics
- describing the technology used to measure the magnitude and location of an earthquake
- describing the limitations of current methods of predicting earthquakes
- explaining how more accurate earthquake predictions could benefit millions of people globally
- analyzing the technology of earthquake-resistant buildings
- explaining the technology used to detect continental drift
- describing the risks and benefits of using a subduction zone for hazardous waste disposal

MAJOR CONCEPTS	KNOWLEDGE

2. **Paleontology, the scientific study of ancient life, uses fossils as the primary source of data.**	*Students should be able to demonstrate an understanding that:*
	• fossils are used in the study of ancient life, by extending from Science 8, Unit 4, the knowledge that the diversity of rocks on Earth today is the result of the diverse processes redistributing components of the original igneous rocks, and by:
	  • describing the radiometric procedures used to estimate the age of minerals and fossils
	  • describing how paleontologists gather and interpret evidence of ancient life
	  • explaining how the layers in sedimentary rock, together with the fossils they contain, form a chronology of natural history
	  • describing common types of fossilization
	  • describing the main characteristics of environment and life forms in the four eras of the geologic time scale: Precambrian, Paleozoic, Mesozoic and Cenozoic
	  • explaining why oxygen was not a significant component of the Earth's atmosphere until photosynthesis and chlorophylls evolved

SKILLS

Students should be able to demonstrate the skills and thinking processes associated with the practice of science by:

- identifying common rock types
- interpreting data from radiometric dating of minerals and fossils
- inferring the relative ages of rock layers, using geologic principles
- making inferences about the characteristics of life forms, based on the fossil record
- making inferences about climate, based on the fossil record

STS CONNECTIONS

Students should be able to demonstrate an understanding of the processes by which scientific knowledge is developed and of the interrelationship of science, technology and society by, among other activities:

- describing the technology of radiometric dating
- identifying local evidence of prehistoric life
- describing the research conducted at the Royal Tyrrell Museum of Paleontology
- explaining the purpose of the cooperative Canada/China paleontological research project
- discussing the costs and benefits of paleontological research

MAJOR CONCEPTS	KNOWLEDGE

3. **The fossil record indicates that the environment and life forms on Earth have undergone a sequence of changes over more than 3.5 billion years.**	*Students should be able to demonstrate an understanding that:*
	• the fossil record indicates that changes in life forms and environment have occurred on Earth, by:
	  • describing the organic theory of formation of fossil fuels
	  • describing the common types of rock formation that serve as reservoirs for oil and gas
	  • explaining how the principles of genetic and natural selection account for the changes in life forms reflected by the fossil record
	  • explaining the view of evolution as a gradual and persistent modification over a very long time
	  • explaining punctuated equilibrium as an alternative view of the pattern of evolution
	  • using the Theory of Evolution to illustrate how scientific theories are developed and revised

4. **The geologic record indicates that huge glaciers have formed in Arctic regions and flowed south over large areas of Canada several times over the last two million years.**	• there is geologic evidence for the existence and causes of the ice ages by:
	  • describing how repeated glaciation has shaped the topography and formed the drainage patterns of Canada
	  • explaining how ice cores taken from polar icecaps provide evidence of the global climate over more than a hundred thousand years
	  • explaining how the geometry of the Earth's orbit around the sun could account for periods of glaciation
	  • explaining how changes in the composition of the atmosphere could cause major changes in the Earth's climate
	  • discussing current predictions of global warming in a geologic timeframe.

SKILLS

Students should be able to demonstrate the skills and thinking processes associated with the practice of science by:

- evaluating the traditional view of evolution as a gradual and persistent modification of life forms over a very long time
- evaluating the punctuated equilibrium view of evolution which states that evolution of life forms is characterized by bursts of rapid change alternating with long, relatively stable periods
- interpreting topographical features and drainage patterns in terms of past glaciation
- making inferences about ancient environmental conditions from the composition of ice cores taken from polar icecaps
- evaluating and synthesizing current predictions of global climate change.

STS CONNECTIONS

Students should be able to demonstrate an understanding of the processes by which scientific knowledge is developed and of the interrelationship of science, technology and society by, among other activities:

- explaining why fossil fuel reserves are finite
- explaining the importance of a knowledge of fossils in oil exploration
- explaining the importance of seismic surveying in oil exploration
- discussing the nature of science as a way of knowing compared to other ways of knowing
- describing the technology used to analyze ice core samples
- exploring alternative policies aimed at slowing global warming.

Science 20

Unit 2 Changes in Living Systems

Overview

Science Themes: *Energy*, *Change* and *Systems*

In Unit 2, students investigate the biogeochemical cycling of several elements through the biosphere and its component ecosystems. *Energy* flow is studied by following energy through the trophic levels of an ecosystem. The characteristics that define an ecosystem are studied through examples of terrestrial and aquatic ecosystems that are within the experience of the students and close to where they study. At these levels of organization, biological *systems change* over time, so that a community within an ecosystem may be succeeded by a different one.

This unit builds upon Science 10, Unit 1: Energy from the Sun, and and Unit 2: Matter and Energy in Living Systems, and provides students with a foundation for the study of interaction of human organisms with their environment (in Science 30), as well as the further study of ecology.

The five **major concepts** developed in this unit are:

- matter cycles through the biosphere
- energy flows through the biosphere
- ecosystems are defined by a range of characteristics
- ecosystems often change over time
- organisms are adapted to their environments.

In this unit, students will develop an ability to use the **skills** and **thinking processes** associated with the practice of science, including:

- collecting and recording
- organizing and communicatingd
- analyzing data from their investigation of living systems.

The **STS connections** in this unit illustrate:

- the central role of experimental evidence in the accumulation of knowledge, and the way in which proposed theories may be supported, modified or refuted
- the functioning of products or processes based on scientific principles
- the ways that science advances technology and technology advances science.

Attitudes

Students will be encouraged to:

- appreciate the unity of science through the application of physical and chemical principles and measurements to biological systems
- appreciate that biological principles emerge from the investigation of the structures and functions of biological systems
- appreciate the fact that biological principles apply to all levels of biological organization
- appreciate that biological systems change over time in ways that are difficult to predict
- appreciate that because of the difficulties of making scientific predictions, scientists must show respect for evidence, tolerate uncertainty and remain objective as they persevere in their desire to understand biological systems
- appreciate that our understanding of biological systems has been enhanced by the application of technology, particularly by the development of instruments to make measurements and manage data
- appreciate that the application of technology by human societies can have beneficial and harmful effects on biological systems.

MAJOR CONCEPTS	KNOWLEDGE
	Students should be able to demonstrate an understanding that:

1. **Matter cycles through the biosphere.**	• matter cycles through the biosphere changing location and chemical combination, by extending from Science 10, Unit 1, the relationship between solar energy and the hydrologic cycle, and by:
	  • describing the hydrologic cycle in detail including the underground movement of water
	  • describing the biogeochemical cycles of carbon, oxygen and nitrogen

2. **Energy flows through the biosphere.**	• solar energy cycles through ecosystems, by extending from Science 10, Unit 2, how solar energy is trapped by photosynthesis and by:
	  • describing how energy moves through trophic levels through food chains and webs
	  • explaining how trophic levels can be described in terms of pyramids of numbers, biomass or energy
	  • explaining the energetic basis of biotic relationships like competition, predation and symbiosis

SKILLS	STS CONNECTIONS
Students should be able to demonstrate the skills and thinking processes associated with the practice of science by:	*Students should be able to demonstrate an understanding of the processes by which scientific knowledge is developed and of the interrelationship of science, technology and society by, among other activities:*
• measuring the rates of precipitation and evaporation in an area of their learning centre and comparing their data to long-term trends	• describing the importance of aquifers in supplying fresh water to many parts of the world
• monitoring the rates of water consumption and loss in plants and animals, and hypothesizing about how the environment might alter them	• assessing the risks and benefits of using deep well injection to dispose of waste materials
• formulating hypotheses on how alterations in the carbon cycle as a result of the burning of fossil fuels might influence other cycling phenomena, and suggesting how the hypotheses could be tested	• drawing parallels between materials recycling programs in their community and biogeochemical cycles in nature
• communicating the results of their work in clearly written reports	• analyzing the biogeochemical cycling of carbon and the greenhouse effect, with respect for evidence and tolerance of uncertainty
	• evaluating the impact of technology on the biogeochemical cycles of nitrogen and the methods of influencing that impact
• constructing, from data on the calorific values of various organisms, a food chain to show the numbers of organisms consumed at each level	• describing how the movement of energy and matter through food chains and webs may also concentrate pollutants by the process of biological magnification
• carrying out a simulation to test their hypotheses on the relationship between predators and prey	• evaluating the implications of the introduction of exotic species into an ecosystem where natural predators do not exist, and methods of dealing with the consequences of such introductions

MAJOR CONCEPTS	KNOWLEDGE
	Students should be able to demonstrate an understanding that:
3. **Ecosystems are defined by a range of characteristics.**	• ecosystems are defined in terms of physiographic, climatic, edaphic and biotic factors, by: • explaining how those factors influence an aquatic and a terrestrial ecosystem in the region of their learning centre such as a stream or lake, prairie, boreal forest or sports field

4. **Ecosystems often change over time.**	• primary and secondary succession is a natural process in the ecosystems chosen, by:
	  • describing the stages involved in the primary succession of those ecosystems and the nature of their climax communities
	  • describing possible pathways of secondary succession after natural or artificial disturbance

5. **Organisms are adapted to their environments.**	• how populations of plant and animal species adapt to a changing environment, by:
	  • describing a range of variation in species and populations
	  • explaining the principles of fitness and natural selection
	  • exploring the limitations on the sizes of populations.

SKILLS	STS CONNECTIONS
Students should be able to demonstrate the skills and thinking processes associated with the practice of science by:	*Students should be able to demonstrate an understanding of the processes by which scientific knowledge is developed and of the interrelationship of science, technology and society by, among other activities:*
• measuring abiotic factors like pH, temperature, hardness and oxygen content in the freshwater ecosystem chosen, and relating those values to the community in the ecosystem • investigating the makeup of a soil community in the ecosystem chosen, and inferring the relationships between the organisms found there	• reviewing the factors that may influence the natural quality of water in freshwater systems, with an emphasis on intellectual honesty • debating, in an open-minded way, the impact of the draining of wetlands for "reclamation"
• setting up and observing the pattern of succession in a microenvironment; tabulating, graphing and interpreting relevant data, then comparing these with data produced by others	• evaluating the impact on society of secondary succession following disturbance in natural ecosystems
• examining homologous structures in a range of fossil and living species and inferring the adaptive significance of variations observed • performing an experiment or a simulation on the growth of a population of organisms, and hypothesizing how the trends observed would affect human populations.	• discussing the nature of science as a way of knowing, compared with other ways of knowing • drawing analogies between the origin of new species by natural selection in the biosphere and the production of new life forms by biotechnology • analyzing why the growth of human populations is different to that of natural populations.

Science 20

Unit 3
Chemical Changes

Overview

Science Themes: *Change* and *Matter*

In Unit 3, students investigate the *changes* that occur in *matter* during chemical reactions, including oxidation/reduction and organic reactions. Students are introduced to the quantitative aspects of chemical change within the context of some of the chemical reactions that are used in Alberta chemical industries.

The unit builds upon Science 8, Unit 1: Solutions and Substances, and Science 10, Unit 3: Matter and Energy in Chemical Change, and provides students with a foundation for the further study of chemistry.

The four **major concepts** developed in this unit are:

- aqueous solutions provide a convenient medium for chemical *changes*
- balanced chemical equations show the quantitative relationships among the reactants and products involved in chemical reactions
- oxidation and reduction reactions involve a transfer of electrons
- hydrocarbons are the starting substances for many organic compounds.

In this unit, students will develop an ability to use the **skills** and **thinking processes** associated with the practice of science, including:

- collecting and recording
- organizing and communicating
- analyzing data from their investigation of chemical change.

The **STS connections** in this unit illustrate:

- the functioning of products or processes based on scientific principles
- the use of technology to solve practical problems
- the ability and responsibility, through science and technology, that society has to protect the environment and judiciously use natural resources to ensure quality of life for future generations.

Attitudes

Students will be encouraged to:

- develop a questioning attitude and a desire to understand more about matter and its changes
- develop an awareness of the importance of water as a medium for chemical reactions
- appreciate that observations are the foundation for generalizations and explanations about chemical change
- develop an appreciation for the usefulness and importance of stoichiometric methods in science and in industry
- appreciate that science and technology provide many useful products
- appreciate the importance of careful laboratory techniques and precise calculations for obtaining accurate results
- value the need for safe handling and disposal of chemicals.

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MAJOR CONCEPTS	KNOWLEDGE

1. **Aqueous solutions provide a convenient medium for chemical changes.**	*Students should be able to demonstrate an understanding that:*
	• aqueous solutions provide a convenient medium for chemical changes, by extending from Science 8: Unit 1, the meaning of the terms solute, solvent, solution, dissolving and solubility, and by:
	  • providing examples from living and non-living systems in which the dissolution of substances in water is a prerequisite for chemical change
	  • differentiating on the basis of properties among electrolytes, non-electrolytes, acids and bases
	  • relating the properties of a solution to the nature of the dissolved species
	  • using chemical names and formulas for dissolved substances, acids and bases
	  • calculating the concentration of solutions in moles per litre and calculating mass or volume when the concentration is known
	  • determining the concentration of diluted solutions and the quantities of a solution and water to use when diluting
	  • explaining solubility in terms of dynamic equilibrium

2. **Balanced chemical equations show the quantitative relationships among the reactants and products involved in chemical reactions.**	• the mole ratios in balanced chemical reaction equations provide quantitative information about the substances involved, by recalling from Science 10: Unit 3, how to balance chemical equations, and by: • predicting, using gravimetric and solution stoichiometry, quantities of products/reactants involved in chemical reactions

SKILLS

Students should be able to demonstrate the skills and thinking processes associated with the practice of science by:

- using laboratory chemicals according to WHMIS regulations and guidelines for safe storage and handling
- disposing of used laboratory chemicals, using safe and accepted procedures
- investigating the properties of solutions in the laboratory
- using a balance and volumetric glassware to prepare solutions of specified concentrations
- determining experimentally the identity of some common ions, using simple qualitative tests such as colour and solubility
- communicating the findings of their investigations in a clearly written report

STS CONNECTIONS

Students should be able to demonstrate an understanding of the processes by which scientific knowledge is developed and of the interrelationship of science, technology and society by, among other activities;

- identifying from personal experience examples of chemical changes that occur in aqueous solution
- relating what they have learned about the properties of electrolytes, non-electrolytes, acids and bases to solutions encountered in everyday life
- comparing the ways that concentrations of solutions are expressed in the chemistry lab, in industry, in household products and in environmental studies
- evaluating the importance of concentration in risk management
- explaining how the concentration of toxins in an ecosystem is increased by biological magnification
- describing the processes involved in water treatment plants

- using unit analysis to check the results of mathematical calculations
- performing an experiment that illustrates the validity of the assumptions contained in stoichiometric methods
- evaluating the design of stoichiometric experiments

- applying stoichiometric methods to the chemical reactions involved in the production of urea and phosphate fertilizers

MAJOR CONCEPTS	KNOWLEDGE
	Students should be able to demonstrate an understanding that:

3. **Oxidation and reduction reactions involve a transfer of electrons.**	• many chemical reactions involve oxidation and reduction, by:
	  • defining oxidation and reduction
	  • applying the principles of oxidation and reduction to explain the operation of electrolytic and galvanic cells
	  • using stoichiometry based on electrode half-reactions to predict the quantities of products formed in electrolytic cells

4. **Hydrocarbons are the starting substances for many organic compounds.**	• hydrocarbons are the basis for many common organic compounds, by:
	  • stating the general characteristics of hydrocarbons
	  • naming and providing structural formulas for simple hydrocarbons in the homologous series of alkanes, alkenes, alkyne
	  • describing the important reactions of hydrocarbons, such as combustion, addition, substitution and polymerization
	  • identifying hydrocarbons as a source of energy in fossil fuels
	  • describing and naming some important petrochemicals that are produced from hydrocarbons.

SKILLS	STS CONNECTIONS
Students should be able to demonstrate the skills and thinking processes associated with the practice of science by:	*Students should be able to demonstrate an understanding of the processes by which scientific knowledge is developed and of the interrelationship of science, technology and society by, among other activities;*
• constructing, observing and describing an electrolytic cell	• identifying examples of oxidation-reduction that occur in their everyday lives
• constructing, observing and describing a galvanic cell	• providing examples of how technology has addressed the problem of corrosion; e.g., cathodic protection, galvanizing
	• explaining how electrolysis is applied in the metal extraction and electroplating industries
	• describing the design characteristics of a successful battery
• using safe substances and procedures investigate in the laboratory, the chemical properties of hydrocarbons and other selected organic compounds.	• providing examples of hydrocarbons and petrochemicals that are used on a daily basis
	• explaining briefly the processes of fractional distillation and catalytic cracking and reforming
	• describing the ethylene industry in Alberta.

Science 20

Unit 4 Changes in Motion

Overview

Science Themes: *Change*, *Equilibrium* and *Systems*

In Unit 4, students investigate *change* through the study of motion and the forces that cause motion. Students' understanding of *equilibrium* and *systems* is developed through the study of conservation of momentum. Designing of the safety devices used in transportation and sports provides the context for learning basic mechanical principles.

This unit builds upon Science 7, Unit 3: Force and Motion, and Science 10, Unit 4: Energy and Change, and provides a foundation for the further study of mechanics.

The four **major concepts** developed in this unit are:

- the motion of objects is described in terms of displacement, time velocity and acceleration
- Newton's Laws of Motion relate force to the motion of objects
- an object moving in a circular path with a constant speed undergoes an acceleration toward the centre of the circle
- momentum is conserved in physical interactions.

In this unit, students will develop an ability to use the **skills** and **thinking processes** associated with the practice of science, including:

- collecting and recording
- organizing and communicating
- analyzing data from their investigations of changes in motion.

The **STS connections** in this unit illustrate:

- the functioning of products or processes based on scientific principles
- the ways that science advances technology and technology advances science
- the influence of the needs, interests and financial support of society on scientific and technological research.

Attitudes

Students will be encouraged to:

- appreciate the need for computational competence in quantifying motion and momentum
- appreciate the need for empirical evidence in interpreting observed phenomena
- appreciate the restricted nature of evidence when interpreting the results of physical interactions
- accept uncertainty in the descriptions and explanations of motion in the physical world
- appreciate the need for accurate and honest communication of all evidence gathered in the course of an investigation
- objectively evaluate potential applications of mechanical principles to new technology
- appreciate the role the principles of mechanics play in our everyday world.

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MAJOR CONCEPTS	KNOWLEDGE
	Students should be able to demonstrate an understanding that:

1. **The motion of objects is described in terms of displacement, time velocity and acceleration.**	• motion is described in terms of displacement, time, velocity and acceleration, by extending from Science 10, Unit 4, the principles of one-dimensional uniform motion, and by:
	  • comparing and contrasting scalar and vector quantities
	  • comparing and contrasting distance and displacement, and speed and velocity
	  • defining velocity as a change in displacement during a time interval
	  • defining acceleration as a change in velocity during a time interval
	  • explaining uniform motion and uniform accelerated motion problems using graphical and mathematical techniques

2. **Newton's Laws of Motion relate force to the motion of objects.**	• Newton's Laws of Motion describe the effects of forces on the motion of bodies, by extending from Science 7, Unit 3, the concepts of force, inertia and friction, and by:
	  • comparing and contrasting mass, volume and weight
	  • explaining how a force effects a change in motion
	  • applying Newton's First Law of Motion to explain an object's state of rest or uniform motion
	  • defining momentum as a quantity of motion equal to the product of the mass and the velocity of an object
	  • applying Newton's Second Law of Motion and using it to relate force, mass and motion
	  • relating a change in momentum to acceleration
	  • applying Newton's Third Law of Motion to explain a change in momentum and impulse when objects interact

SKILLS	STS CONNECTIONS
Students should be able to demonstrate the skills and thinking processes associated with the practice of science by:	*Students should be able to demonstrate an understanding of the processes by which scientific knowledge is developed and of the interrelationship of science, technology and society by, among other activities:*
• gathering data necessary to infer the relationships among acceleration, velocity and time • determining velocity, displacement and acceleration from position–time and velocity–time graphs • obtaining new data from graphs by determining the slope of a curve and the area under a curve • designing an experiment to determine the local value of the acceleration due to gravity • using unit analysis to check the results of mathematical solutions	• explaining the principles of motion involved in simulating "zero gravity" conditions on an aircraft (as used by NASA) • explaining the principles of motion involved in determining safe lengths for runways at airports and entrance and exit ramps on freeways
• gathering data necessary to infer the relationships among acceleration, force and mass • evaluating the design of their mechanics experiments • solving algebraically linear motion problems, using Newton's Second Law of Motion • solving linear motion problems involving friction • communicating the findings of their investigations in a clearly written report	• explaining the movement of passengers in a car changing speed and/or direction in terms of the Law of Inertia • explaining the role of the principles of mechanics in the design and use of safety equipment, such as air bags and collapsible bumpers in cars • discussing the role of the principles of mechanics in establishing legal restrictions, such as seat belts and speed limits • explaining the role of the principles of mechanics in the design of safety equipment, such as helmets, goggles and safety ropes in sports

MAJOR CONCEPTS	KNOWLEDGE
	Students should be able to demonstrate an understanding that:

3. **An object moving in a circular path with constant speed undergoes an acceleration toward the centre of the circle.**	• uniform circular motion requires a constant unbalanced force, by:
	  • describing uniform circular motion as a special case of two-dimensional motion
	  • describing a centripetal force as one of several varieties; e.g., gravitational, friction, electrostatic
	  • applying the centripetal force and acceleration equations to uniform circular motion
	  • applying Newton's Universal Law of Gravitation to explain planetary and satellite motion
	  • explaining how Kepler's laws were used to derive Newton's Universal Law of Gravitation

4. **Momentum is conserved in physical interactions.**	• the total momentum of any system of revolving or colliding bodies remains constant in the absence of outside forces, by:
	  • applying the Law of Conservation of Momentum to linear collisions and explosions
	  • explaining linear one-dimensional collisions and explosions, using graphical and mathematical means
	  • explaining qualitatively the conservation of angular momentum in rotating objects.

SKILLS	STS CONNECTIONS
Students should be able to demonstrate the skills and thinking processes associated with the practice of science by:	*Students should be able to demonstrate an understanding of the processes by which scientific knowledge is developed and of the interrelationship of science, technology and society by, among other activities:*
• designing, performing and evaluating an experiment to investigate the relationship between centripetal force and centripetal acceleration • solving satellite motion problems, using the circular motion approximation	• discussing the principles of a centrifuge and its applications in industry and research • explaining the principles of mechanics involved in producing artificial gravity conditions in carnival rides and space stations • describing the technological and scientific principles involved in designing a rotating space station • discussing day-to-day life on a space station • explaining the technological advantages of "zero gravity" conditions for research and manufacturing • evaluating objectively the costs and benefits of designing and building a rotating space station
• designing, performing and evaluating an experiment that illustrates the Law of Conservation of Momentum • using vector addition to solve one-dimensional linear momentum problems.	• discussing how conservation of momentum principles are used by the police in traffic accident investigations • explaining how spinning figure skaters and gymnasts change their rate of rotation.

Science 30

Unit 1
Living Systems Respond to Their Environment

Overview

Science Themes: *Equilibrium* and *Systems*

In Unit 1, students investigate some of the mechanisms of homeostasis and genetics through the major themes of *equilibrium* and *systems*. The unit focuses on the mechanisms living organisms use to maintain an *equilibrium* with the environment, using the human organisms as a model *system*.

This unit builds upon Science 10, Unit 2: Matter and Energy in Living Systems, and Science 20, Unit 2: Change in Living Systems, and provides a foundation for the further study of the biological sciences.

The four **major concepts** developed in this unit are:

- the circulatory *system* enables the human body to interact with its environment
- the nervous *system* mediates the interaction of humans with their environment
- the human body has defence mechanisms to protect itself from disease-causing organisms and adverse environments
- some human diseases are inherited.

In this unit, students will develop an ability to use the **skills** and **thinking processes** associated with the practice of science, including:

- collecting and recording
- organizing and communicating
- analyzing data from their investigations of changes in motion.

The **STS connections** in this unit illustrate:

- the inability of science to provide complete answers to all questions
- the functioning of products or processes based on scientific principles
- the influence of the needs, interests and financial support of society on scientific and technological research.

Attitudes

Students will be encouraged to:

- appreciate the unity of science through the application of physical and chemical principles and measurements to biological systems
- recognize that biological principles emerge from the investigation of the structures and functions of biological systems
- appreciate that the maintenance of a suitable external and internal environment is important to human health
- recognize that the range of technology used to maintain health is used in a human as well as a scientific context
- appreciate that because of the difficulties of making scientific predictions, scientists must show respect for evidence, tolerate uncertainty and remain objective as they persevere in their desire to understand biological systems
- recognize that death is a natural biological phenomenon.

MAJOR CONCEPTS	KNOWLEDGE

1. **The circulatory system enables the human body to interact with its environment.**	*Students should be able to demonstrate an understanding that:*
	• the circulatory system assists the interaction between all the body's cells and the environment, by extending from Science 10, Unit 2, a knowledge of the processes of diffusion, active transport and osmosis, and by:
	  • describing the structure of the heart, arteries, veins and capillaries, and the path of blood circulation
	  • explaining the functions of the components of blood
	  • explaining the role of the blood in transporting nutrients from the digestive system, wastes and toxins to the kidney and liver, and carbon dioxide and oxygen to and from the lungs
	  • describing the homeostatic regulatory mechanisms controlling cardiac output and blood pressure

2. **The nervous system mediates the interaction of humans with their environment.**	• special sense organs help humans perceive their environment and that the nervous system coordinates responses to that environment, by:
	  • describing the structure and function of the organs of sight, balance and pressure
	  • describing the structure of the nervous system including brain, spinal cord and peripheral nervous system
	  • describing the structure of a neuron, the production of an action potential and the transmission of information across a synapse
	  • explaining the functioning of a reflex arc

SKILLS	STS CONNECTIONS
Students should be able to demonstrate the skills and thinking processes associated with the practice of science by:	*Students should be able to demonstrate an understanding of the processes by which scientific knowledge is developed and of the interrelationship of science, technology and society by, among other activities:*
• observing blood flow in the capillaries of a living organism • observing the nature of blood flow in their own veins • observing, drawing and labelling a dissected mammalian heart • using a microscope to examine the cellular components of the blood • measuring their own blood pressure and investigating the role of exercise in influencing blood pressure • communicating the results of their investigations in clearly written reports	• analyzing how the circulatory system can be involved in the transport of prescription drugs to their sites of action • evaluating how substances in the environment can adversely influence health through the circulatory system • exploring the relationship between exercise and health
• observing, drawing and labelling a dissected mammalian eye • examining an entire and a dissected mammalian brain to identify its major features • examining prepared slides of nerve tissue, and drawing and labelling the main features • designing experiments to investigate their reflex actions	• evaluating health hazards in the environment that might impair the functioning of the sensory systems • describing technological innovations that assist people with induced or inherited sensory deficiencies • analyzing the influence of anesthetics, drugs and chemicals from the environment on the functioning of the nervous system • comparing the nature of control mechanisms in technological systems to those in humans • discussing the biological basis of diseases like Alzheimer's or Parkinson's, with an emphasis on the difficulties of making scientific predictions

MAJOR CONCEPTS	KNOWLEDGE
	Students should be able to demonstrate an understanding that:

3. **The human body has defence mechanisms to protect itself from disease-causing organisms and adverse environments.**	• the specific and non-specific defence mechanisms of the body have a biological basis, by:
	  • explaining the role of the skin in defence and protection
	  • explaining the functioning of the immune system

4. **Some human diseases are inherited.**	• some human diseases and disorders are inherited through the nuclear genome, by extending from Science 10, Unit 2, a knowledge of how cells increase in number by mitosis, and by:
	  • describing, in general, the behaviour of DNA and chromosomes during mitosis and meiosis
	  • describing the behaviour of chromosomes during gametogenesis and fertilization
	  • explaining how the principles of heredity are based on predictable results in mono- and dihybrid crosses
	  • explaining the basis for sex-linked inheritance, for the production of chromosomal abnormalities like those resulting in Down's syndrome, for the production of disorders like cystic fibrosis and phenylketonuria, and the occurrence of mutations.

SKILLS

Students should be able to demonstrate the skills and thinking processes associated with the practice of science by:

- carrying out simulations of the functioning of the immune system
- preparing tissue for microscopic observation of the process of mitosis, observing prepared slides of the process of meiosis, and comparing the two processes
- performing experiments to investigate the relationships between chance and inheritance and inferring their importance to genetics
- investigating in their peer groups or families the presence of single-factor, inherited human traits.

STS CONNECTIONS

Students should be able to demonstrate an understanding of the processes by which scientific knowledge is developed and of the interrelationship of science, technology and society by, among other activities:

- analyzing the biological basis of problems caused by the human immunodefficiency virus (HIV)
- discussing the role of genetic counselling in their society
- discussing the role of gene banks in preserving endangered species and genotypes
- assessing the possible impact of alternative reproductive technology on their society.

Science 30

Unit 2
Chemistry in the Environment

Overview

Science Themes: *Matter*, *Change* and *Systems*

In Unit 4, the role of chemistry in environmental studies is examined, with a focus on the properties and reactions of acids, bases and selected organic compounds. The important effects of synthetic organic compounds and acids and bases on living and non-living *systems* is explored.

This unit builds upon Science 10, Unit 3: Matter and Energy in Chemical Change, and Science 20, Unit 3: Chemical Changes, and provides a foundation for the further study of chemistry.

The four **major concepts** developed in this unit are:

- chemistry is an essential component of environmental studies
- acids and bases affect the chemistry of aqueous systems
- acids and bases have important environmental effects
- organic compounds can have both positive and negative effects.

In this unit, students will develop an ability to use the **skills** and **thinking processes** associated with the practice of science, including:

- analyzing and synthesizing data from their study of chemistry in the environment
- evaluating the procedures used in their study of chemistry in the environment.

The **STS connections** in this unit illustrate:

- the inability of science to provide complete answers to all questions
- the functioning of products or processes based on scientific principles
- the influence of the needs, interests and financial support of society on scientific and technological research.

Attitudes

Students will be encouraged to:

- value the role of precise observation and experimentation in learning about the chemistry of acids, bases and organic compounds
- recognize the need for safe handling, storage and disposal of chemicals
- recognize the limits of current scientific knowledge of complex environmental problems
- demonstrate intellectual honesty, open-mindedness and objectivity when assessing environmental effects caused by chemical change
- appreciate the benefits to society of acids, bases and synthetic organic compounds
- recognize that the application of technology by human societies can have beneficial and harmful effects on biological systems
- value the role of chemistry in monitoring the environment and in understanding and working to resolve environmental problems
- develop an awareness of the need for evaluating environmental issues from a variety of perspectives.

MAJOR CONCEPTS	KNOWLEDGE
	Students should be able to demonstrate an understanding that:

1. **Chemistry is an essential component of environmental studies.**	• chemistry is an essential component of environmental studies, by:
	  • outlining the chemical reactions that lead to the production of air pollutants such as sulphur dioxide, nitrogen oxides and photochemical smog
	  • outlining briefly the evidence indicating that CFCs are involved in the depletion of the ozone layer
	  • indicating the source of water pollutants that are of major concern, such as, phosphates, hydrocarbons, organic matter and heavy metals
	  • explaining the sampling protocols and analysis techniques used in monitoring air and water quality
	  • describing briefly some methods used to monitor air and water quality, such as, tests for BOD, heavy metals and organic compounds in water, and tests for particulate matter, aerosols and specific gases in air
	  • explaining briefly the scientific principles involved in municipal water treatment and sewage treatment plants

SKILLS

Students should be able to demonstrate the skills and thinking processes associated with the practice of science by:

- using standard procedures for collecting and testing samples of air and water
- evaluating sources of error in air and water quality testing
- developing and testing a method for purifying air or water
- identifying variables and controls in environmental studies
- designing an experiment to investigate seasonal variations in the composition of air or water in their community
- communicating the findings of their investigations in a clearly written report
- drawing block diagrams to represent the processes used in municipal water treatment and sewage treatment plants

STS CONNECTIONS

Students should be able to demonstrate an understanding of the processes by which scientific knowledge is developed and of the interrelationship of science, technology and society by, among other activities:

- investigating local sources of air and water pollution
- evaluating local programs for reducing air and water pollution
- formulating a personal plan of action for improving the environment
- investigating local water treatment and sewage treatment procedures
- describing the chemical principles involved in technology designed to reduce air pollution
- reviewing current issues involving chemistry in the environment from a variety of perspectives

MAJOR CONCEPTS	KNOWLEDGE

2. **Acids and bases affect the chemistry of aqueous systems.**	*Students should be able to demonstrate an understanding that:*
	• acids and bases affect the chemistry of aqueous systems by:
	  • defining acids and bases in terms of the Bronsted Lowry concept
	  • differentiating between strength and concentration using examples of organic and inorganic acids
	  • explaining the significance of the ionization constant for water, Kw, in terms of equilibrium principles
	  • explaining what is meant by strong and weak acids and bases, in terms of equilibrium principles
	  • calculating $H_3O^+(aq)$ ion or $OH^-(aq)$ ion concentration, using Kw and/or pH
	  • determining pH from $H_3O^+(aq)$ ion and $OH^-(aq)$ ion concentrations
	  • using stoichiometry and titration data to determine the concentration of an acid or a base
	  • explaining how buffers maintain a relatively constant pH when small amounts of acid or base are added to an aqueous system
	  • explaining the importance of maintaining a relatively constant pH in living systems
	  • explaining the colour changes of indicators in terms of the Bronsted Lowry concept

SKILLS

Students should be able to demonstrate the skills and thinking processes associated with the practice of science by:

- using laboratory chemicals according to WHMIS regulations and guidelines for safe storage and handling
- disposing of used laboratory chemicals, using safe and accepted procedures
- using a pH meter and/or pH paper to measure the pH of some common household substances
- using diagnostic tests to differentiate among acids, bases, neutral ionic and neutral molecular compounds
- using diagnostic tests to differentiate among strong and weak acids and bases
- designing, carrying out and evaluating a titration experiment to determine the concentration of an acid or base solution;
- designing, carrying out and evaluating an experiment to test buffer action

STS CONNECTIONS

Students should be able to demonstrate an understanding of the processes by which scientific knowledge is developed and of the interrelationship of science, technology and society by, among other activities:

- describing the use of acids and bases in common household products such as foods and cleaning agents
- describing the common industrial uses of hydrochloric acid and sodium hydroxide
- describing the commercial production of hydrochloric acid and sodium hydroxide
- describing how to handle an accidental acid or base spill, using dilution and neutralization
- explaining why ingesting acidic foods does not lower the pH of the body fluids
- describing simple household methods for removing scale from kettles, humidifier pads/rolls, and cleaning battery terminals

MAJOR CONCEPTS	KNOWLEDGE
	Students should be able to demonstrate an understanding that:

3. **Acids and bases have important environmental effects.**	• acids and bases have an important effect on the environment, by:
	  • outlining the procedures and regulations governing the safe storage, handling and disposal of acidic and caustic chemicals
	  • writing reaction equations to represent the production, prevention and treatment of acid rain components
	  • describing changes to the environment caused by acid rain, such as accelerated corrosion, metal leaching from bedrock and the physiological effect on living organisms
	  • explaining what is meant by the buffering capacity of soil
	  • explaining why lowering the pH of lakes and streams has an adverse effect on aquatic life

4. **Organic compounds can have both positive and negative environmental effects.**	• the environmental effect of organic compounds can be both positive and negative, by recalling from Science 20, Unit 3, the source of petrochemicals, and by:
	  • identifying alcohols, aldehydes, ketones, organic acids, amines and esters from the functional groups in their structure and providing the names, formulas and uses of common members of the above categories of compounds
	  • defining and giving examples of natural and synthetic polymers
	  • describing the chemical and physical processes involved in converting natural wood fibre into paper
	  • providing examples of synthetic polymers and pesticides, and describing their properties and uses
	  • providing examples of the effect of synthetic polymers and pesticides on living systems
	  • tracing the possible movement of a pesticide through an ecosystem, identifying any harmful effects that could occur.

SKILLS

Students should be able to demonstrate the skills and thinking processes associated with the practice of science by:

- constructing an acid rain simulator
- using maps to illustrate the role of weather in the distribution patterns of acid deposition
- designing, carrying out and evaluating an investigation of some of the environmental effects of acid rain
- evaluating technology for reducing acid rain or its effects
- researching current information on the effects of acid rain on agriculture, aquaculture and forestry

STS CONNECTIONS

Students should be able to demonstrate an understanding of the processes by which scientific knowledge is developed and of the interrelationship of science, technology and society by, among other activities:

- identifying some everyday instances that require knowledge of how to handle acids and bases such as sulphuric acid in car batteries, sodium hydroxide in household cleaners
- examining, from a variety of perspectives, the issue of transporting acidic and caustic substances through populated areas
- explaining how burning sour gas at well sites contributes to acid deposition
- analyzing, from a variety of perspectives, some methods being used to reduce the incidence and effects of acid rain, such as reducing the sulphur content of coal, collecting sulphur dioxide emissions to make sulphuric acid, and liming lakes
- explaining what is meant by a "technological fix" attitude

- investigating the properties of representative alcohols, aldehydes, ketones, organic acids, amines and esters
- designing and carrying out an investigation to test the effect of light on the breakdown of various kinds of plastics
- investigating the feasibility of degradable plastics
- investigating through experimentation or research, the action of a pharmaceutical or pesticide
- preparing a synthetic polymer and investigating its properties.

- explaining the role of fossil fuels in the synthesis of useful compounds
- reviewing, in an open-minded way, the issues related to the production and use of petrochemicals
- assessing the risks and benefits associated with the use of polymers and pesticides
- reviewing, in an objective and open-minded way, the environmental issues related to dioxins and furans
- describing both positive and negative effects of current and past developments in the field of synthetic organic chemistry
- evaluating alternatives to pesticide use.

Science 30

Unit 3 Electromagnetic Energy

Overview

Science Themes: *Diversity* and *Energy*

Unit 3 focuses on energy transmission by means of electromagnetic waves. The entire electromagnetic spectrum is studied, from the very long low-frequency radio waves through visible light waves to very short high-frequency gamma rays. The *diverse* applications of electromagnetic *energy* in scientific research and telecommunications are emphasized. The unit concludes with the role electromagnetic radiation plays in the study of the history and structure of the universe.

This unit builds upon Science 9, Unit 4: Electromagnetic Systems, and Science 20, Unit 1: The Changing Earth, and provides a foundation for the further study of electromagnetism.

The four **major concepts** developed in this unit are:

- field theory is one of the most important ideas in modern science
- field theory can be used to explain the operation of many important electric devices
- the electromagnetic spectrum is a continuous range of electromagnetic waves with specific characteristics and similar properties
- the study of the history and structure of the universe uses the entire electromagnetic spectrum.

In this unit, students will develop an ability to use the **skills** and **thinking processes** associated with the practice of science, including:

- collecting and recording
- analyzing
- connecting, synthesizing and integrating data from their investigations of the electromagnetic spectrum.

The **STS connections** in this unit illustrate:

- the functioning of products or processes based on scientific principles
- the ways that science advances technology and technology advances science
- the influence of the needs, interests and financial support of society on scientific and technological research.

Attitudes

Students will be encouraged to:

- appreciate the need for empirical evidence in interpreting observed phenomena
- appreciate the need for accurate and honest communication of all evidence gathered in the course of an investigation
- objectively assess information about, and technological applications of, electromagnetic radiation
- objectively evaluate new information about the universe gathered using telecommunication technology
- recognize the restricted nature of evidence gathered using telecommunication technology
- recognize that the ongoing developments in telecommunications are a result of the interaction between science and technology
- appreciate the need for safety precautions when working with electricity.

MAJOR CONCEPTS	KNOWLEDGE

1. **Field theory is one of the most important ideas in modern science.**	*Students should be able to demonstrate a qualitative understanding that:*
	• the field concept explains action at a distance by:
	  • defining a field as a sphere of influence around a source
	  • comparing and contrasting scalar and vector fields
	  • describing the basic characteristics of all vector fields – source, direction and strength of field as determined by a test object
	  • comparing and contrasting gravitational, magnetic and electric fields in terms of basic characteristics

2. **Field theory can be used to explain the operation of many important electric devices.**	• field theory can be used to explain the operation of devices used to produce, transmit and transform electrical energy, by:
	  • describing the relationships among current, voltage and resistance using Ohm's law
	  • comparing series and parallel circuits in household wiring
	  • distinguishing between direct current and alternating current in terms of electron movement and electric field
	  • describing the advantages of alternating current over direct current for transmitting and using electrical energy
	  • describing how electric fields can produce magnetic fields and how magnetic fields can produce electric fields
	  • explaining the operation of a transformer in terms of changing electric and magnetic fields

SKILLS

Students should be able to demonstrate the skills and thinking processes associated with the practice of science by:

- comparing and contrasting the interaction of static electric charges and the interaction of magnetic poles
- drawing diagrams to represent gravitational, magnetic and electric fields

STS CONNECTIONS

Students should be able to demonstrate an understanding of the processes by which scientific knowledge is developed and of the interrelationship of science, technology and society by, among other activities:

- describing examples of fields encountered in everyday experience
- discussing the scientific and/or technological advances that led to the development of devices such as the telephone, tape-recorder and photocopier

- using a mechanical (collision) model to illustrate electric current and resistance in conductors
- calculating any variable in the equation V=IR, given the other two variables
- constructing and analyzing simple series and parallel circuits
- investigating the effect of a conductor moving through a magnetic field
- building a simple electric motor
- comparing and contrasting electric motors and generators
- designing, carrying out and evaluating an investigation of the relationships among the current, voltage and number of turns in the primary and secondary coils of the transformer
- communicating the findings of their investigations in a clearly written report

- explaining the function of fuses, circuit breakers, polarized plugs and grounding wires in household circuits
- describing some current applications of electromagnets
- explaining why care must be taken when working with electricity
- describing the use of transformers in the home and the school
- describing the technology of measuring household electrical energy
- explaining how the cost of electrical energy is calculated
- describing current technology for using electricity more productively, such as lighting efficiency, more efficient motors

MAJOR CONCEPTS	KNOWLEDGE

3. **The electromagnetic spectrum is a continuous range of electromagnetic waves with specific characteristics and similar properties.**	*Students should be able to demonstrate a qualitative understanding that:*
	• the electromagnetic spectrum is a continuous range of electromagnetic waves with specific characteristics and similar properties by extending from Science 20, Unit 2, knowledge of the characteristics of transverse waves, and by:
	  • predicting the effects of changing one or a combination of variables in the relationship $v = f\lambda$ on any one of the remaining variables
	  • explaining that electromagnetic radiation is produced by accelerating charged particles
	  • explaining the propagation of electromagnetic radiation in terms of perpendicular electric and magnetic fields varying with time, travelling away from their source at the speed of light
	  • describing the range of the electromagnetic spectrum from very long, low-frequency radio waves, through visible light waves, to very short high-frequency gamma rays
	  • comparing and contrasting the various constituents of the electromagnetic spectrum on the basis of source, frequency, wavelength and energy
	  • describing the phenomena of reflection, refraction and polarization of visible light
	  • comparing the characteristics of radiation from any region of the electromagnetic spectrum with those of visible light

SKILLS

Students should be able to demonstrate the skills and thinking processes associated with the practice of science by:

- calculating any variable in the equation $v = f\lambda$ given two of the three variables of frequency, wavelength and speed of electromagnetic propagation
- performing and evaluating experiments investigating reflection and refraction of visible light
- performing an experiment demonstrating total internal reflection
- performing an experiment demonstrating the polarization of visible light
- drawing diagrams illustrating amplitude and frequency modulated radio waves
- drawing block diagrams illustrating the components of a radio transmitter, a simple radio receiver and an optical fibre communications system
- investigating and explaining remote sensing technology used to study the atmosphere and the surface of the Earth; e.g., ice movement, crop conditions and forest damage

STS CONNECTIONS

Students should be able to demonstrate an understanding of the processes by which scientific knowledge is developed and of the interrelationship of science, technology and society by, among other activities:

- describing examples of electromagnetic energy encountered in daily life
- discussing the impact of electromagnetic radiation technology on daily activities
- researching and analyzing the current controversy concerning electromagnetic radiations from video terminals and high voltage lines
- describing examples of polarized light encountered in daily life
- describing how fibre optics is used in telephone communication and in medicine
- identifying medical and industrial uses of gamma rays, X-rays and ultraviolet light
- explaining the use of visible light in lasers and videodisks
- explaining the use of infrared light in remote sensing
- describing the use of microwaves and radio waves in telecommunication such as radio and television, satellite communication and radar

MAJOR CONCEPTS	KNOWLEDGE

4. **The study of the history and structure of the universe uses the entire electromagnetic spectrum.**	*Students should be able to demonstrate a qualitative understanding:*
	• the electromagnetic energy emitted by celestial bodies is used in the study of the history and structure of the universe, by:
	  • explaining that nuclear fusion in the sun produces a wide spectrum of electromagnetic radiation
	  • describing how the earth's atmosphere absorbs certain frequencies of electromagnetic radiation
	  • interpreting the composition of objects or substances on the basis of the emission or absorption spectra they produce
	  • describing how the surface temperature of a star can be estimated from the distribution of energy in its spectrum
	  • explaining that the solar system is part of the Milky Way Galaxy, one of billions of galaxies in the universe
	  • explaining the use of the Doppler shift in spectral lines in measuring the speed of distant stars
	  • describing the empirical evidence that indicates that the universe is expanding
	  • describing the empirical evidence for the evolution of stars and the existence of black holes
	  • comparing and contrasting the big bang theory with the steady state theory
	  • identifying the major attributes and components of current models of the universe, specifying supporting scientific evidence.

SKILLS

Students should be able to demonstrate the skills and thinking processes associated with the practice of science by:

- writing equations to represent the nuclear changes occurring in stars
- observing continuous spectrum of sunlight, using a prism or diffraction grating
- observing line spectra, using a diffraction grating
- describing the conditions necessary to produce line emission and line absorption spectra
- observing and describing the colour changes as the temperature of an incandescent object is gradually increased
- investigating and reporting on the use of satellite communication technology in receiving and transmitting information used to study the universe
- using accepted units for expressing astronomical distances
- estimating the age of the universe, assuming current rates of expansion.

STS CONNECTIONS

Students should be able to demonstrate an understanding of the processes by which scientific knowledge is developed and of the interrelationship of science, technology and society by, among other activities:

- describing the role of the ozone layer in filtering ultraviolet radiation
- explaining how the study of cosmic rays have increased our understanding of the universe and the structure of matter
- describing in general terms the operation of earth-based optical and radio telescopes
- describing the technological developments that enable use of the entire electromagnetic spectrum in cosmology
- evaluating objectively the role of satellites and space probes in extending our knowledge of the universe
- illustrating, using examples, the need for open-mindedness in the search for scientific explanations of observed phenomena
- evaluating the costs and benefits of cosmological research from a variety of perspectives
- speculating on how the universe began and how it might end.

Science 30

Unit 4
Energy and the Environment

Overview

Science Themes: *Energy* and *Systems*

In Unit 4, students investigate the potential of a wide range of renewable and non-renewable *energy* sources to provide for global *energy* needs. In considering the merits of alternative energy sources, the major guiding principle is that the global demand for energy must be reconciled with the need for a viable global *ecosystem*.

This unit builds on the concepts of energy and systems developed in Science 10, Unit 1: Energy from the Sun, and Unit 4: Energy and Change; and in Science 20, Unit 1: The Changing Earth, Unit 2: Changes in Living Systems, and Unit 3: Chemical Changes.

The four **major concepts** developed in this unit are:

- the global demand for *energy* must be reconciled with the need to maintain a viable biosphere
- the Sun is the Earth's main source of *energy*
- mass is converted to energy in nuclear reactions
- the interaction of the gravitational fields of the moon is the source of tidal *energy*.

In this unit, students will develop an ability to use the **skills** and **thinking processes** associated with the practice of science, including:

- organizing and communicating
- analyzing, synthesizing and integrating data from their investigations of energy and the environment
- evaluating the processes used in their investigations of energy and the environment.

The **STS connections** in this unit illustrate:

- the functioning of products or processes based on scientific principles
- the use of technology to solve practical problems
- the ability and responsibility, through science and technology, that society has to protect the environment and judiciously use natural resources to ensure quality of life for future generations.

Attitudes

Students will be encouraged to:

- appreciate the unity of science through the application of principles from biology, chemistry, physics and earth science to the study of energy and the environment
- appreciate the need to reconcile the global demand for energy with the need to maintain a viable global ecosystem
- be concerned with the efficient use and conservation of energy resources globally and locally
- appreciate that issues related to energy and the environment involve the interrelationship of science, technology and society
- be open-minded when considering the merits of alternative energy sources
- consider all the evidence available when evaluating alternative energy sources
- develop a questioning attitude concerning the environmental impact of current and future energy sources.

MAJOR CONCEPTS	KNOWLEDGE
	Students should be able to demonstrate an understanding that:

1. **The global demand for energy must be reconciled with the need to maintain a viable biosphere.**	• global energy demands must be reconciled with maintaining a viable biosphere by:
	  • describing the exponential growth of global energy consumption
	  • explaining the importance of more efficient energy use in a global energy strategy
	  • explaining the term, "sustainable development"
	  • describing the environmental impact of developing various energy sources, such as offshore oil, windpower, nuclear fission
	  • identifying renewable energy sources that have the potential to provide a greater share of global energy needs

2. **The Sun is the Earth's main source of energy.**	• the sun is the Earth's main source of energy by extending from Science 10, Unit 1, a knowledge of the Sun's role in photosynthesis and weather, and by:
	  • indicating what proportion of the solar radiation striking Earth creates the wind, powers the water cycle and drives photosynthesis
	  • describing the conversion of radiant solar energy into thermal and electrical energy
	  • explaining how wind and water power originate in the Sun
	  • explaining how the energy stored in fossil fuels originated in the Sun
	  • using heats of formation to predict heats of combustion for different fuels
	  • comparing cellular respiration to the combustion of fuels

SKILLS

Students should be able to demonstrate the skills and thinking processes associated with the practice of science by:

- interpreting graphs of current and projected energy consumption
- analyzing energy consumption by various sectors of industry; e.g., metallurgy, petrochemical, pulp and paper
- designing and constructing a hot water heater and calculating its efficiency
- drawing analogies between the Sun heating the Earth as a closed system and heating a home as a closed system
- comparing graphically the commercial potential of various renewable energy resources, such as solar power, wind power, hydropower and biomass
- designing, carrying out and evaluating an experiment to compare the efficiency of different types of solar collectors
- designing, carrying out and evaluating an experiment to investigate the factors influencing the output of photovoltaic cells
- designing, carrying out and evaluating an experiment to compare the heat produced by different fuels
- communicating the findings of their investigations in a clearly written report

STS CONNECTIONS

Students should be able to demonstrate an understanding of the interrelationship of science, technology and society by, among other activities:

- evaluating the consequences for the biosphere of Canada's per capita energy consumption
- identifying and evaluating ways of using energy more efficiently in the home and community
- describing how commercial buildings harbour tremendous potential for energy savings
- describing recent technology that led to more efficient energy use
- assessing the environmental impact of the primary local energy source, such as hydroelectric power, coal burning power station
- discussing ancient and modern technology for directly harnessing solar energy
- analyzing design constraints in solar heated buildings
- identifing and evaluating ways that passive solar heating can be used to reduce heating costs of homes and schools
- describing new technology for harnessing wind, water and biomass energy
- evaluating government policies that would encourage the commercial development of renewable and non-renewable energy resources
- evaluating various fuels from the perspective of heat content, economics and environmental impact

MAJOR CONCEPTS	KNOWLEDGE
	Students should be able to demonstrate an understanding that:

3. **Mass is converted to energy in nuclear reactions.**	• mass is converted to energy in nuclear reactions, by:
	  • outlining the sequence of events in the fusion of hydrogen that results in the production of solar energy
	  • applying quantitatively mass/energy equivalency to the hydrogen fusion reaction
	  • describing the current state of fusion research
	  • explaining the difference between fission and fusion reactions
	  • describing the operation of a fission reactor, such as CANDU
	  • comparing quantitatively the energy produced by nuclear, chemical and phase changes
	  • describing how nuclear fission could be the source of geothermal energy

4. **The interaction of the gravitational fields of the moon and earth is the source of tidal energy.**	• the interaction of the gravitational fields of the Moon and Earth is the source of tidal energy by:
	  • explaining the source of tides in terms of Newton's Law of Universal Gravitation and the relative motions of the Moon and the Earth
	  • describing the energy transformations involved in converting tidal energy into electrical energy.

SKILLS

Students should be able to demonstrate the skills and thinking processes associated with the practice of science by:

- observing evidence of radioactive decay in a cloud chamber
- writing equations to represent nuclear reactions
- applying in quantitative terms mass/energy equivalency to fission and fusion reaction
- comparing and contrasting conventional and nuclear power stations
- schematically representing the energy input, conversion and output in a nuclear reactor
- doing a cost/benefit analysis of a nuclear power station
- doing a cost/benefit analysis of a geothermal power station

STS CONNECTIONS

Students should be able to demonstrate an understanding of the interrelationship of science, technology and society by, among other activities:

- debating the expenditure of public money on fusion research
- analyzing the risks and benefits of nuclear energy
- explaining why nuclear energy is sometimes referred to as the "unforgiving technology"
- explaining the connection between nuclear energy and hot springs resorts in the Canadian Rockies
- describing new technology designed to harness geothermal energy

- using library resources to research the potential of tidal power
- comparing and contrasting tidal power with hydro power.
- describing the technology required to harness the Bay of Fundy tides
- analyzing the risks and benefits of constructing tidal power stations.

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